

[THEORY SERIES LOGO HERE]

# General Ecology

The New Ecological Paradigm

**EDITED BY ERICH HÖRL  
WITH JAMES BURTON**

Bloomsbury Academic

An imprint of Bloomsbury Publishing Plc

B L O O M S B U R Y

LONDON • OXFORD • NEW YORK • NEW DELHI • SYDNEY

# CONTENTS

*List of Contributors* vii

*Acknowledgments* xii

*Series Preface* xiv

- 1 Introduction to general ecology: The ecologization of thinking 1

*Erich Hörl*

- 2 Computational logic and ecological rationality 75

*Luciana Parisi*

- 3 Elements for an ecology of separation: Beyond ecological constructivism 101

*Frédéric Neyrat*

- 4 General ecology, economy, and organology 129

*Bernard Stiegler*

- 5 The modern invention of nature 151

*Didier Debaise*

- 6 Deep times and media mines: A descent into ecological materiality of technology 169

*Jussi Parikka*

- 7 Planetary immunity: Biopolitics, Gaia theory, the holobiont, and the systems counterculture 193

*Bruce Clarke*

- 8 Ecologizing biopolitics, or, What is the “bio-” of biopolitics and bioart? 217

*Cary Wolfe*

- 9 Ecologies of communion, contagion, &c, especially Bataille 235

*David Wills*

- 10 Metafiction and general ecology: Making worlds with worlds 253

*James Burton*

- 11 An ecology of differences: Communication, the Web, and the question of borders 285

*Elena Esposito*

- 12 Specters of ecology 303

*Timothy Morton*

- 13 Devastation 323

*Matthew Fuller and Olga Goriunova*

- 14 Virtual ecology and the question of value 345

*Brian Massumi*

*Index* 375

## CHAPTER 7

# Planetary immunity

## Biopolitics, Gaia theory, the holobiont, and the systems counterculture

*Bruce Clarke*

### **Biopolitics and the immunitary paradigm**

Biopolitics concerns the thinking together of issues of sovereignty and governmentality with the matter of life, predominantly but not exclusively human life. Standard biopolitical topics include the eugenics movement of the earlier twentieth century, especially as it brought about laws for racial hygiene; also, the dire outcome of eugenic initiatives in the Nazi death camps; and, in contrast to such “thanatopolitical” events, the post-war normalization of the welfare state in advanced industrial nations. In this sampling, the political themes are clear enough, but the bio- of biopolitics leaves nonhuman life largely out of the equation. In his introduction to a French edition of Italian philosopher Roberto Esposito’s work on biopolitics, Frédéric Neyrat writes: “Of course, life protects itself, ‘by nature’; but modern sovereignty must be thought of as a second, ‘meta-immunitary’ ‘dispositif’ that, coming from life itself, separates itself from it, and forms a transcendent instance that bears down on life to the extent that it destroys it.”<sup>1</sup> However, what appear to be Neyrat’s assumptions about “life” and its “nature” leap over a number of biological and ecological issues of great import to the aim of Esposito’s project as Neyrat describes it, “to make impossible any transcendent normativity, which will always have as its effect to prescribe a dreadful distinction between a good life on the one hand, and on the other hand a life that deserves only death or abandonment.” (36)



This chapter also seeks to question notions of immunopolitical transcendence, with an inquiry into the possibility of thinking Gaia theory and biopolitics together, of thinking the form of a Gaian biopolitics.

Francisco Varela's second-order systems-theoretical characterization of the theory provides a succinct synopsis of the strand of Gaia discourse on which I will stake my argument:

We all are used to thinking that the biosphere is constrained by and adapted to its terrestrial environment. But the Gaia hypothesis proposes that there is a circularity here: this terrestrial environment is itself the result of what the biosphere did to it. As Lovelock puts it metaphorically: we live in the breath and bones of our ancestors. As a result the entire biosphere/Earth "Gaia" has an identity as a whole, an adaptable and plastic unity, acquired through time in this dynamic partnership between life and its terrestrial environment.<sup>2</sup>

To make a start, then, on the construction of a Gaian biopolitics, Cary Wolfe's *Before the Law: Humans and Other Animals in a Biopolitical Frame*, given its concern to extend biopolitical discussion beyond humans alone, offers this enquiry a posthumanist if not altogether planetary orientation.<sup>3</sup> *Before the Law* sets about deconstructing some key pairs of distinctions endemic to standard biopolitical thought, such as proper / improper and inside / outside, while pressing them toward the immunitary form of these dialectics, in Wolfe's words, "the 'immunitary' (and, with Derrida, 'autoimmunitary') logic of the biopolitical."<sup>4</sup> His note to this remark cites Esposito's *Immunitas: The Protection and Negation of Life*.<sup>5</sup> While Esposito's text does not take nonhuman animals and their possible standing "before the law" into its purview, it too drives beyond standard biopolitical discussion by delving deeply into some key histories of modern biology and physiology. *Immunitas* draws out the multivalent development of the notion of immunity from its classical roots as a political concept of individual exemption from communal demands to a modern biomedical concept of organic exemption from the harm borne by environmental pathogens: "But if the notion of immunity only takes form against the backdrop of meaning created by community," Esposito remarks, "how are we to characterize their relationship? Is it a relation of simple opposition, or is it a more complex dialectic in which neither term is limited to negating the other but instead implicates the other, in subterranean ways, as its necessary presupposition?" (5).

*Immunitas* unfolds in great detail what turns out to be an exceedingly complex dialectic between the concepts of immunity and community. However, once the issue of immunity in relation to community is posed in its biological provenance, where is one to stop? Could one not reconfigure one's view of the community of the living, whatever the vagaries and variations of its immunitary situations, in order to extend it to Gaia's planetary horizon? Esposito appears to gesture in that direction at the end of his work *Bios: Biopolitics and Philosophy*, in particular, through a reflection on a remarkable, proto-ecological passage from Spinoza's *Ethics*:



So if something in Nature appears to us as ridiculous, absurd, or evil, this is due to the fact that our knowledge is only partial, that we are for the most part ignorant of the order and coherence of Nature as a whole, and that we want all things to be directed as our reason prescribes. Yet that which our reason declares to be evil is not evil in respect of the order and laws of universal Nature, but only in respect of our own particular nature.<sup>6</sup>

However, according to Wolfe, Esposito draws from Spinoza's defense of Nature's right to exist on its own terms the contemporary imperative that "a turn away from the thanatological and autoimmunitary logic of biopolitics can only take place if life as such—not just human (vs animal) life ... becomes the subject of immunitary protection," which absolute imperative amounts to a form of "biologistic continuism."<sup>7</sup> Some of the issues here may be stated like this: does such "immunitary protection" refer to political and legal or to biological and ecological matters? Can such protections be applied to both at once? And in either case, can such protections really be referred to "life as such" as opposed to some forms of life rather than others? Wolfe comments: "Where Esposito is wrong is in his insistence on 'the principle of unlimited equivalence for every single form of life'"; for this leads him dangerously close to "a sort of neovitalism that ends up radically dedifferentiating the field of 'the living' into a molecular wash of singularities that all equally manifest 'life.'"<sup>8</sup>

Wolfe counters Esposito's Deleuzian route to an affirmative biopolitics with an alternative model that develops the operational isomorphism between immunitary and autopoietic systems, and so insists instead on the necessity to observe biological and social differentiations in the midst of their integration into higher-order ensembles.<sup>9</sup> We will come back to this in the context of biologist and evolutionary theorist Lynn Margulis's formulation of the Gaian system as an autopoietic system in its own right. But for the moment let us return to Esposito's *Immunitas*. This is a crucial text precisely for its author's candor in declaring how the more recent immune-system theorizing available to him around the year 2000 disorients the dialectical approach he has brought to the topic. As we will see, it is this more recent immune discourse, significantly inflected by the work of Francisco Varela and Humberto Maturana, that can be effectively marshalled for something like a Gaian ecopolitics of planetary immunity.<sup>10</sup> Encountering this constructivist school of immunological thought, Esposito's own dialectical inquiry into the self / non-self distinction reaches the limits of its paradigm. Let us look quickly at how Esposito presents this instructive impasse in his introduction to *Immunitas*.

Given how the full text of his study will detail the manifold conceptual cul-de-sacs, the dismaying hypertrophies of militaristic metaphors, and other negativities, contradictions, and self-destructive dynamics of the immunitary paradigm, it makes good sense for Esposito to preview the shift in tone to come at the end of this book. He asks: "Is there a point at which



the dialectical circuit between the protection and negation of life can be interrupted, or at least problematized? Can life be preserved in some other form **that** that of its negative protection?" (16). Must biopolitics always devolve into a thanatopolitics where the lives of some are protected by the putting to death of others, or could there be an affirmative biopolitics that might avert the sorts of murderous episodes commonplace in the twentieth century? The biological turn in Esposito's philosophy is driven by this quest for a non-facile form of biotic affirmation: "I have sought the answer to the question with which I began at the very heart of the protective mechanism that has progressively extended itself to all the languages of life—namely, on the biological plane, in the immune system that ensures the safeguarding of life in the body of each individual" (16). However, upon lengthy examination of the modern discourse of the immune system, affirmation is not easy to come by. Indeed, according to biomedical and immunological discourse from the time of Pasteur to the time of AIDS, vertebrate immune systems succeed in protecting their possessors against the onslaughts of the viruses, the bacteria, and the killer fungi only by placing their beneficiaries on uncertain hair-triggers against autoimmune fiascos. Life is war, pathogenicity is everywhere, and your best friend could be your worst enemy.

It is against this dismal immunitary vista that Esposito locates incipient glimmers of an alternative view:

However, more recent study of the structure and functioning of the immune system seems to suggest another interpretive possibility, one that traces out a different philosophy of immunity ... This new interpretation situates immunity in a nonexcluding relation with its common opposite. The essential point of departure ... is a conception of individual identity that is distinctly different from the closed, monolithic one we described earlier ... Rather than an immutable and definitive given, the body is understood as a functioning construct that is open to continuous exchange with its surrounding environment. (17)

Indeed, he concludes, "once its negative power has been removed, the immune is not the enemy of the common, but rather something more complex that implicates and stimulates the common" (18). Admirably, however, he confesses that "the full significance of this necessity, but also its possibility, still eludes us" (18). I will venture to suggest that in this remark Esposito sees clearly enough that the old dialectical machinery of self and non-self no longer provides an adequate description of immune functions, but also, that he cannot yet see how to fit these newer observations into some other comprehensive scheme. But in the subsequent development of immunological theory, that alternative scheme and its significance have taken on sharper outlines. A key element of these newer conceptions of the immune system concerns its ecological extension beyond the "immune self." This revision to the immunitary paradigm is amenable to a Gaian

description of biological community coordinated with ecological environments, a view that lifts the immunitary paradigm up to a planetary horizon.

## Gaia and the systems counterculture

A set of planetary discourses published several decades ago already indicated how to expand the immunitary paradigm beyond the old ontologies of the self. Current biopolitical thought provides an apt occasion to consolidate some of these abiding theoretical leads. They originated with the architects of Gaia theory, Lynn Margulis in particular, in the milieu of a larger systems counterculture including William Irwin Thompson and Francisco Varela. If the power of their combined vision has since lain semi-dormant in a state of relative obscurity, or submerged under insipid or bastardized versions of their insights, I hope to extract the actual detail of that conceptual vision from such neglect for renewed appreciation. Some narration and commentary from a 1986 NOVA documentary will give us a preview of our destination:

Narrator: Geologists use changes in fossils to date the history of the world. And the record shows that mass extinctions have happened repeatedly. Is this a failure of Gaia? Or has life been under attack from the outside, and survived? The answer may lie in the large craters scattered around the earth's surface. One popular though controversial theory holds that they were caused by asteroids or comets hitting the earth. The effect of an impact great enough to cause such craters would be devastating. It's calculated that the shock would be a thousand times that of all of the world's nuclear weapons going off in one place. The effect would be to throw up a blanket of dirt and debris, which would circulate around the world, blocking out the sun, freezing the continental areas, killing most plants and animals. How could the Gaian system have survived such a devastating blow?

Lynn Margulis: Gaia is run by the sum of the biota, and therefore you can lose enormous numbers and great diversity with mass extinctions, but you never come anywhere near losing everything, and you certainly don't lose the major groups of bacteria, ever. They've been in continuous existence, and we think it's the major groups of bacteria that actually are running the Gaian system. So in a sense these—whether they're caused by impact or whatever they're caused by—these great extinctions are tests of Gaia, and the system bounces back.<sup>11</sup>



Several intellectual venues helped to cultivate the Gaia concept such that its immunitary implications would eventually take on a specifically biopolitical inflection. The first of these venues is the *Whole Earth Catalog*, with its



persistent foregrounding of “whole systems.” Such “wholeness” was not precisely a medical, psychological, or spiritual ideal, although those connotations are always available. In the beginning, the “whole Earth” named a desire to see a photograph taken from space of the full earth, like the full moon, unobscured by shadow.<sup>12</sup> But once that technical image did arrive in 1967, the wholeness in question was explicitly *synergetic* in the sense popularized by the original intellectual hero of the *Catalog*, Buckminster Fuller, synergy being the “unique behavior of whole systems, unpredicted by the behavior of their respective subsystems’ events.”<sup>13</sup> As filled out by its regular opening section, “Understanding Whole Systems,” the *Catalog*’s vision of wholeness is broadly cybernetic, systems-theoretical: it is the operational wholeness of a systemic process bounded with a closed organizational loop while driven by a material-energetic flux. The outside back cover of the *Catalog*’s second major iteration in Spring 1969 figured this initial orientation toward far-from-equilibrium thermodynamic systems by placing the following statement next to an image of Earthrise: “*the flow of energy through a system acts to organize that system.*”<sup>14</sup> The self-organizing system in question is clearly the whole earth in solar context.

Among the many wider repercussions of the *Whole Earth Catalog* as it expanded in size and mutated in form over the next two decades was its availability to a conceptual gathering I call the systems counterculture. In the late sixties, the systems thinkers favored by the *Catalog* featured, preeminently, Buckminster Fuller, as well as the inventor of the term *cybernetics*, Norbert Wiener, and also, less famously but more importantly for future developments, cyberneticist Heinz von Foerster, who provided the *Catalog*’s editor, Stewart Brand, with a seminal review of George Spencer-Brown’s calculus for constructivism, *Laws of Form*.<sup>15</sup> After the prematurely named *Last Whole Earth Catalog* of 1971, it was three years before the *Catalog* project reappeared in new forms. One of these was the *Whole Earth Epilog*, released in September 1974. For our narrative the key development here is the arrival of Gregory Bateson in the wake of his signature collection of 1972, *Steps to an Ecology of Mind*. The influence of Bateson now eclipsed that of Fuller, leading Brand during the 1970s to prefer whole systems thinking purveyed through less technological, more anthropological and ecological varieties of cybernetics.<sup>16</sup> This development is epitomized by the major mutation of the occasional *Catalog* into a quarterly journal that began operation in the spring of 1974—the *CoEvolution Quarterly* (CQ).

The cover of the first CQ wonderfully captures this ecological shift. We observe **the face of coevolution as** a profusion of myriad coevolutionary relationships gathering together insects and flowers, sea creatures and oceans, microbes and galaxies, an image Gaian in spirit if not in letter. Meanwhile, with Bateson as its primary standard bearer, the systems counterculture began to gather within the pages of CQ. An early number included an announcement for a voluntary community formed in 1972 by a scholarly prodigy and lapsed Yeats expert turned poet and cultural historian, William



Irwin Thompson. Thompson had already published two widely distributed trade books, *At the Edge of History: Speculations on the Transformation of Culture* in 1971 and *Passages About Earth: An Exploration of the New Planetary Culture* in 1974. During that period he founded the Lindisfarne Association as an esoteric community with a contemplative orientation toward an intellectual agenda taking up the cultivation of a “Planetary Culture and the New Image of Man.” We will come back shortly to Bill Thompson and his place within the systems counterculture.

Lynn Margulis and James Lovelock arrive in *CQ*’s Summer 1975 issue, making it the first non-specialist journal to publish on Gaia, with what was still a distinctly specialized treatment.<sup>17</sup> Their headnote begins: “We would like to discuss the Earth’s atmosphere from a new point of view—that it is an integral, regulated, and necessary part of the biosphere,” and in the article proper they restate the main point: “The purpose of this paper is simply to present our reasons for believing the atmosphere is actively controlled” (30, 32). The discussion regarding “regulation” and “control” is in a distinct idiom of engineering cybernetics. And the object of discussion is still relatively modest: it is not precisely the whole earth or the biosphere in its entirety but a specific component thereof, the atmosphere as systemically coupled to the biota. Early Gaia discourse reconceived the evolution and composition of the contemporary atmosphere not as the abiotic lucky happenstance of traditional geology but as a system regulated by and integrated with the biota, and as a necessary outcome of living, largely microbial processes. This construction was heretical then, but settled science now: the air we aerobic organisms breathe to stay alive is itself biogenic. In overwhelming proportions it comes from life and forms the earthly repository—both sink and source—wherein the gaseous wastes of living metabolisms circulate in and out of organic capture and use. Lovelock and Margulis’s atmosphere hypothesis was also cybernetic to the core: the peculiarly far-from-equilibrium and biologically viable composition of the atmosphere is the emergent outcome of a closed loop of biogeochemical cycles at the planetary level, held in homeostasis, that is, feedback-regulated, throughout geological time “by and for” the biota.<sup>18</sup>

Another member of the systems counterculture arrives in the Summer 1976 issue of *CQ*. Francisco Varela is the subject of a fine interview that lays out some of the original conceptuality of second-order cybernetics.<sup>19</sup> Carl Sagan, Margulis’s ex-husband, had recommended her to Brand, but how does an unknown émigré Chilean neurobiologist make such a dramatic debut in the pages of *CQ*? In fact, his mentor, Humberto Maturana’s good friend and colleague, Heinz von Foerster, had put Varela forward, who thereby quickly came to the notice of the California systems intelligentsia. That same summer, Varela attended the “Mind / Body Dualism Conference” organized by Brand and Bateson and attended by von Foerster and others, and that fall, *CQ* published his conference contribution, “Not One, Not Two,” which material he would incorporate into his first book, *Principles*

of *Biological Autonomy*, published three years later.<sup>20</sup> “Not One, Not Two” formulates the post-dialectical epistemology of second-order systems theory, for which “dualities are adequately represented” neither by negation nor polarity but, rather, “by *imbrication* of levels, where one term of the pair *emerges* from the other.”<sup>21</sup> I call this logical modality *double positivity*, as in the mutually supplementary relation of systems and their environments. Gaian applications would be to observe, first, that the Gaian system emerged from the dynamical coupling of the primeval biota to the planetary surface to form a geobiosphere, and next, that from that moment on, all earthly environments within the Gaian sphere have co-emerged from or in structural relation to the operations of living systems in the same measure that living beings have had their terms of existence in correlation with the contingencies, affordances and limitations, of their enabling environments.

In CQ for Winter 1978 we come upon another encounter with William Irwin Thompson.<sup>22</sup> What one would not have been able to learn from the pages of CQ is that for several years now his Lindisfarne Association had run a Fellow-in-Residence program. The first Lindisfarne residential fellow was Gregory Bateson in 1976, while he was working on his final book, *Mind and Nature: A Necessary Unity*, followed by Varela in 1977 and 1978, during which time he completed *Principles of Biological Autonomy*. While the residential component of Lindisfarne gradually waned, its major activity continued in the form of annual symposia, which Thompson approached as a master intellectual impresario with an intensive rigor manifest in organization, strategic invitation, and discursive preparation. Gathered from several Lindisfarne events in the 1980s, but based in particular on the 1981 meeting, in 1987 Thompson published the collection *Gaia—A Way of Knowing: Political Implications of the New Biology*.<sup>23</sup> With some significant anticipations on the part of Stewart Brand’s operations at CQ, and adding in a dash of continental flavor with the inclusion of the French theoretical biologist Henri Atlan, *Gaia—A Way of Knowing* assembles in one prime location the top tier of the systems counterculture.

This impression is only strengthened by the fact that, although he is not present in the volume, von Foerster also spoke at the 1981 Lindisfarne meeting that forms the core of the volume. Moreover, in assembling the “new biology” for political interrogation, Thompson places the Gaia concept in direct relation to his vision of a planetary culture. With the general ecological theorist Bateson participating in absentia and the key theorist of second-order cybernetics von Foerster present but off-stage, *Gaia—A Way of Knowing* seizes and synthesizes the epistemological suggestions implicit in all of the countercultural systems biologies on hand. These have now emerged full-blown in Lovelock’s first-order cybernetic Gaia hypothesis crossed with Margulis’s signature discourse of microbial symbiosis, placed alongside Maturana and Varela’s inspired application of second-order cybernetics, defining biological self-reference, operational autonomy, and cognitive capacity through the concept of autopoiesis.

Working out a planetary cultural synthesis of the new systems biologies, Thompson develops that discourse in terms that are distinctly at home in second-order systems theory: “what I am offering in this book is not so much a description of some scientific theories but an unfoldment in which *the observer of the scientific observer changes the science of the scientist*. The literary writer, the poet, becomes possessed by science, and in reflecting the work back to the scientist, the scientist sees his image transformed.”<sup>24</sup> Thompson’s second-order observation acts not as a mere reception and sorting operation but as a new construction in its own right, specifically as a determination of cultural values proper to the artist’s role. And with hindsight it is rather stunning that his terms, as in the phrase below, “politics of life,” leap out to us now as precisely *biopolitical*. Thompson gets all the way there by adding the element of mindfulness in the discourse of autopoietic cognition to the feedback circuit between Gaia and the biota. His preface to the *Gaia* volume concludes:

The Gaia hypothesis alone would not be enough to express the way of knowing or the politics of life. With the atmospheric chemistry of Lovelock, we have the macrocosm; with the bacteriology of Margulis we have the microcosm, but moving between the macrocosm of the planet and the microcosm of the cell is the mesocosm of the mind. It is here in the cognitive biology of Maturana and Varela that knowing truly becomes the organization of the living that brings forth a world. (10)

Drawn from his introductory remarks at the 1981 Lindisfarne meeting, the introduction following Thompson’s preface to the *Gaia* volume begins by noting Bateson’s absence—he would die within a month—while explicitly addressing the wider cybernetic transformations in which he was a crucial participant as one of the key thinkers “responsible for opening up new paths in cybernetics, epistemology, and self-organizing systems biology.”<sup>25</sup> Toward the conclusion of a set of detailed remarks drawing out and linking up the conceptual interconnections of the systems counterculture into an overarching view, Thompson speculated that “if food-sharing is the fountainhead and source of our original humanity, then we most truly perform that humanity when we share food and see with Lewis Thomas in his *Lives of a Cell* that the whole earth is a single cell and that we are simply symbiotic organelles involved with one another. There can be no ‘us’ and ‘them.’ The global politics that issues forth from this vision is truly a *bios* and a *logos*” (25–6). In what he calls elsewhere *Gaia politique*, Thompson indicates again the biopolitical substance of his intervention. Importantly, he notes that our symbiotic coupling with the rest of life in a “single” Gaian “cell” is not universal merger but dynamic differentiation leading to higher coevolutionary complexity:

The fundamental principle that I see coming out of this new mode of thought is that living systems express a dynamic in which opposites are


basic and opposition essential. One cannot say that the ocean is right and the continent is wrong in a Gaian view of planetary process. What this means for me is that the movement from archaic industrial modes of thought into a new planetary culture is characterized by a movement from ideology to an ecology of consciousness. (27)

Let us skip ahead one more time. The May 1988 Lindisfarne Fellows meeting in Perugia, Italy, became the basis for a subsequent Gaia collection, *Gaia 2—Emergence: The New Science of Becoming*. Once again the core group is Lovelock, Margulis, and Varela. From its contents I single out for quick summary just one article, which will close the circle for now on our recovery of a discourse of planetary immunity from within the systems counterculture. Co-written with Mark Anspach, Varela's contribution to *Gaia 2* is "Immu-knowledge: The Process of Somatic Individuation." Finalized around 1990, this article reviews the newer immunology being developed throughout the 1980s, including the network theory of Niels Jerne and the work on immune system autonomy and cognition in Varela's collaborations with Nelson Vaz, Antonio Coutinho, and others. It is this work and its continuation throughout the 1990s that enters Roberto Esposito's narrative at the end of *Immunitas*. The following passage, from which I cited an excerpt early in this chapter, sketches the main argument:

The alternative view we are suggesting can be likened to the notion of Gaia claims that the atmosphere and earth crust cannot be explained in their current configurations (gas composition, sea chemistry, mountain shapes, and so on) without their direct partnership with life on Earth. We all are used to thinking that the biosphere is constrained by and adapted to its terrestrial environment. But the Gaia hypothesis proposes that there is a circularity here: this terrestrial environment is itself the result of what the biosphere did to it. As Lovelock puts it metaphorically: we live in the breath and bones of our ancestors. As a result the entire biosphere/Earth "Gaia" has an identity as a whole, an adaptable and plastic unity, acquired through time in this dynamic partnership between life and its terrestrial environment ... Let us transpose the metaphor to immunobiology, and suggest that the body is like Earth, a textured environment for diverse and highly interactive populations of individuals. The individuals in this case are the white blood cells or lymphocytes which constitute the immune system. (69)

Varela and Anspach go on to write that one must "drop the notion of the immune system as a defensive device built to address external events," and, instead, "conceive it in terms of self-assertion, establishing a molecular identity by the maintenance of circulation levels of molecules through the entire distributed network [... ] This idea is strictly parallel to the species network giving an ecosystem an identity within an environment" (78–9).

## Exit the individual, enter the holobiont

In comparing the immune system to an ecosystem, and ultimately, to Gaia altogether, Varela anticipated by two decades some of the most exciting contemporary work on the symbiotic nature of immunological regimes. This work has been based in recent years on the arrival of genome-sequencing technology capable of unraveling the molecular detail of symbioses among host organisms and their microbiomes.<sup>26</sup> And while no one person gets full credit for the current shift in the view of symbiosis from a marginal to a pervasive phenomenon, the systems counterculture's evolutionary biologist Lynn Margulis deserves a major portion of it.<sup>27</sup> Indeed, after the full run of Margulis's scientific career, symbiosis is no longer a just a biological issue, and biology is no longer a self-contained object of knowledge. In a symbiotic view, biology is always also ecological and geobiological, or, in a word, Gaian. 

Precisely defined, symbiosis is the temporary or permanent living-together of two or more different organisms in bodily contact. Close relations between, say, a human and a domestic animal may be termed companionate, but they are not symbiotic in this strong sense. The permanent mutualistic relation of fungal nodules—mycorrhizae—growing on and into plant roots: this is symbiosis. Yet symbiosis was once a doubtful, even derided topic in biology, because its emphasis on ensembles and collectives of living beings ran counter to the larger discipline's inheritance of Western and modern valorizations of individuality. Proper biology was to be concerned with individual organisms, or individual species, or individual populations of the same species, all caught up in a struggle for life with the survival of the fittest individuals, and so forth, and so on. Indeed, “the Darwinian view of life regarded aggregates of individuals of common ancestry as identifiable units in competition with one another.”<sup>28</sup> And in its fixation on molecular biology, neo-Darwinism—the gene-centered synthesis of Darwinian evolution through natural selection with molecular genetics—drove this philosophical commitment to unitary units and singular causes down to the genetic bone, with what Gilbert et al. state as the “one-genome / one-organism doctrine of classical genetics” (330), declaring that one specific genome alone must account for all the distinct traits of each individual of each species.

The second edition of Margulis's major scientific text, *Symbiosis in Cell Evolution: Microbial Communities in the Archean and Proterozoic Eons*, presents the mature version of her most famous scientific contribution, *serial endosymbiosis theory*, or SET. Here symbiosis is accorded a central role in the early evolution of life's quantum jumps in complexity. The term Margulis uses for this particular symbiotic dynamic is *symbiogenesis*—the development of new life forms by the incorporation or colonization of one or more organisms into or by one another. As restated through Carl



Woese's three-domain idiom, over life's first three billion years, symbiogenesis names the step-by-step evolutionary assembly of the eukaryotic or nucleated cell, and thus, of the domain Eukaryota—all life forms composed of eukaryotic cells—out of a viable symbiotic / symbiogenetic microbial consortium coupling the two evolutionarily prior domains, as an Archean host accepts a series of Eubacterial partners.<sup>29</sup>

*Symbiosis in Cell Evolution* also discusses in passing some non-microbial manifestations of symbiosis, and in the process, Margulis provided terms that have gained a new currency. For instance, the lichen exhibits the fecundity of symbiotic possibilities. In all of their varieties, lichens arise from the opportunistic but non-obligatory integration of a fungus with either an alga or a bacterium: "The integrated symbionts (holobionts) become new organisms with a greater level of complexity."<sup>30</sup> Lichens are emergent cross-kingdom holobionts with their own peculiar properties, organisms wholly built out of dissociable symbiotic partnerships. More commonly, however, symbioses evolve toward obligate status, such as those endosymbioses that have locked together the previously independent components of the eukaryotic cell. Mutualistic symbionts joined in a holobiont typically arrive at permanent and obligatory accommodations, and the newer understanding is that virtually all plants and animals have never been free-standing or pure individuals but, instead, from the evolutionary get-go, host partners to a holobiont containing an indispensable complement of microbial symbionts.

Traditional accounts of evolution have been strongly zoocentric, treating the microbial relations of animals as either peripheral or pathological. Being animals ourselves, we identify with their seeming discreteness as separate, individuated organisms. However, the recent literature of symbiosis has paid particular attention to the cross-domain relations between animals and bacteria in the evolutionary formation and distributed functions of holobionts that encompass both domains. Evolving from the largely microbial world of the pre-Cambrian seas prior to fungi or plants, animals emerged out of and within a biospheric matrix of microbes, a microcosm within which they have always been ecologically integrated and from which they can never viably depart.<sup>31</sup> With such developments, the newer sciences of symbiosis are in the process of *ecologizing* immunology and biology altogether.<sup>32</sup> McFall-Ngai et al. write:

Viewing bacterial colonization of animals as an ecological phenomenon adds clarity to an understanding of the mechanisms and routes by which phylogenetically rich and functionally diverse microbial communities become established and evolve on and within animal hosts. An ecological perspective influences not only our understanding of animal-microbiome interactions but also their greater role in biology. The ecosystem that is an individual animal and its many microbial communities (i.e., the holobiont) does not occur in isolation but is nested within communities of other organisms that, in turn, coexist in and influence successively

larger neighborhoods comprising ever more complex assemblages of microbes, fungi, plants, and animals. (3233–4)

Moreover, the microbial-animal holobiont possesses multiple and specific organ-system niches for particular activities and select populations of the diverse symbionts they support. These include the gut or digestive system, the circulatory system, and the central nervous system. Gilbert, Sapp, and Tauber's "Symbiotic View of Life" draws out the systemic foundations of symbiotic relations: "Only with the emergence of ecology in the second half of the 19th century did organic *systems*—comprised of individuals in cooperative and competitive relationships—complement the individual-based conceptions of the life sciences." They note how the prior Darwinian fixation on biological individuals no longer fits the new evidence: "Symbiosis is becoming a core principle of contemporary biology, and it is replacing an essentialist conception of 'individuality' with a conception congruent with the larger systems approach now pushing the life sciences in diverse directions" (326).

What had traditionally been taken to be the nature of individuality has now been shown to be an inadequate construction. Every "individual" animal is always already a multi-systemic, multi-genomic holobiont host. Gilbert et al. mount a sustained attack on the residual ideology of biological individualism, revealing its roots in pre-scientific philosophical ideas. In contemporary symbiotic science, then, the concept of individuality is having its "natural" credentials revoked, revealing instead that concept's deep participation in Western idealism's metaphysics of essence. Their essay deconstructs the modes of biological individuality piece by piece. For instance, for traditional anatomy, "the individual animal is regarded as a structured whole"; but now, "the term 'holobiont' has been introduced as the anatomical term that describes the integrated organism comprised of both host elements and persistent populations of symbionts" (327–8). In due course these authors also dismantle the embryological, physiological, and genetic rationales for the thesis of biological individuality.

For instance, in the case of the genetic rationale: "The one-genome / one-organism doctrine of classical genetics has been eclipsed by studies of hereditary symbiosis. Microbial symbionts form a second type of genetic inheritance" (330). Moreover, the neo-Darwinist fixation on allelic variation in nuclear genomes (alleles are subdivisions of the genome that encode specific traits of the phenotype), must yield its grip, because "there is also allelic variation in the human microbiome. The genes of *Bacteroides plebeius* differ in different human populations. The Japanese strain contains at least two genes (horizontally transferred from a marine relative) that enable the bacteria to metabolize complex sugars, such as those found in seaweeds."<sup>33</sup> In this example of epigenetic symbiosis, the gut microbiome of certain Japanese people possesses a microbial symbiont that has incorporated the genetic machinery to digest seaweed by horizontal transfer from



a marine bacterium that presumably entered the gut microbiome along with the seaweed. The marine relative of the gut symbiont did not itself colonize the gut, did not itself become a part of the Japanese holobiont. But by the lateral transfer of some of its genetic complement, it shared its seaweed-digesting metabolic capacity with its gut-dwelling cousin. Now the Japanese seaweed-eater gets more nutrition from it than a non-native person, or, has coevolved to be more fit than strangers are to exploit their indigenous environment. And shooting down dogmatic neo-Darwinist rejections of “group selection,” it turns out that “the entire group—the holobiont—is the selectable entity rather than either host or symbiont alone” (330). The combined genetic make-up of the holobiont has been termed the “hologenome” and has already been elaborated in a “hologenome theory of evolution.”<sup>34</sup> And so down goes, too, the evolutionary rationale for biological individuality.

The recent literature on symbiosis handles another prime topic—the immune system. Once again the genome-sequencing evidence runs counter to the traditional notion that “portrays the immune system as a defensive network against a hostile exterior world,” that the “immune individual rejects anything that is not ‘self’ ... In a fascinating inversion of this view of life, however, recent studies have shown that an individual’s immune system is in part created by the resident microbiome” (330). And if that is so, then what is “self” or “not-self” is not a dialectical discriminating of singular or individual essence but a collective negotiation carried out by the committee comprising the holobiont. Gilbert et al. extend the biopolitical analogs of the situation: “associates in a symbiotic relationship are under the social control of the whole, the holobiont ... If the immune system serves as the critical gendarmerie keeping the animal and microbial cells together, then to obey the immune system is to become a citizen of the holobiont” (332). The prior immunitary paradigm has been stood on its head: the immune system’s primary concern is not to seek out and destroy any and all microbial elements of “not-self,” it is instead to hold together the many selves of the holobiotic ecosystem, comprised of the animal host coupled to its own microbiome, by identifying, tolerating, and recruiting beneficial microbial symbionts. Only the occasional bad microbial actors are targeted for removal.

Echoing Gilbert et al.’s “fascinating inversion” of the individual / symbiont relation, another recent essay strikes the same note of conceptual reversal: “Bacteria also must be seen as an essential part of the vertebrate immune system. The paradigm that the adaptive immune system has evolved to control microbes has been modified to include the concept that the immune system is in fact controlled by microorganisms.”<sup>35</sup> In this new immunitary scenario, the traditional location of control with the *host*—the supposedly controlling metazoan individual providing the protected “environment” of the microbial inhabitants and invaders—is reversed: control is relocated with the encompassed population. The distribution and

reciprocation of agency within the holobiont and the displacement of the biological individual in favor of the holobiont's symbiotic ecology makes it a contemporary avatar of a prior ecological scenario—the inversion of “control” as initially propounded by the Gaia hypothesis.

At first, Lovelock and Margulis framed the Gaia hypothesis as a provocative reversal of the normal scientific axiom that states that life is controlled by and so must adapt itself to its geological host, the abiotic environment. In its upstart period during the 1970s, in a sheer reversal of prior biological common sense, the Gaia hypothesis stated to the contrary that life controls the abiotic environment. In this extreme form it was hooted down by its mainstream critics. However, as their science developed beyond its first decade, Gaia's theoreticians saw that, once systemic self-regulation emerges from the synergy of the entire ensemble, the inherited distinction between life and its environment is no more absolute than that between any of the partners of a holobiotic consortium. The science of Gaia graduates from hypothesis to theory with the recognition—aptly expressed in Varela's formulation cited earlier—that neither life nor its planetary medium is so fundamental that either can be said to control the other. Rather, after four billion years of coevolution, living processes, symbiotic organizations, and the sum of their global niches are all relative to ongoing reformulation by evolving eons of matter, life, and sun. Geobiological history has thoroughly churned them all together into a planetary holobiont that maintains, defends, but also surpasses its parts. Just as symbiosis is no longer just a biological matter but must now be seen as an ecological principle, an all-pervasive geobiological dynamic—so, too, “Gaia is symbiosis seen from space.”<sup>36</sup>

## The system bounces back

Consequently, and in full vindication of Margulis's predictions about the fundamental role of symbiosis for the biosphere altogether, the old, static “immune self” has been jettisoned in favor of the holobiont—the ecologically distributed and environmentally dynamic and conserved consortium of a fungal, plant, or animal host and its microbial symbionts. And, as we have seen, when Varela addressed his close colleagues Margulis, Lovelock, and Thompson at the 1988 Lindisfarne meeting, his treatment of “immuno-knowledge” expressed a remarkable, explicitly Gaian turn, pushing the ecosystem metaphor all the way to the planetary horizon. It is not only, as explicitly articulated by Thompson in his introduction to *Gaia 2*, that “Gaia, in essence, is the immune system of our planet.”<sup>37</sup> It is also, as explicitly articulated by Varela and Anspach, that the immune system itself may be taken as operating “like a microcosmic version of Gaia” (69). In the new immunitary paradigm already under construction in Varela's bioscience, the

defensive function is subordinated to an “individual molecular identity” of which Gaia is the molar outcome. The counterpart to the protection of life is not the negation of that which threatens it but the affirmation of its dynamic continuity. Like Gaia or the biosphere, any given immune system has “stability and plasticity”:

The point is not to deny that defense is possible, but to see it as a limiting case of something more fundamental: individual molecular identity ... . Defensive responses, the center of attention in medical immunology, are secondary acquisitions... . Or in the Gaian metaphor, certainly the stability and plasticity of the eco/biosphere has been remarkably successful in coping with, say, large meteoric impacts. But such events were rare, and it seems odd to say that ecosystems evolved because of those events. (81–2)

The point is also this: if, after a serious planetary infection such as that produced by the evolution of the cyanobacteria, which precipitated the “oxygen holocaust” that forever changed the early biosphere, or if, after a traumatic planetary injury such as the meteoric impact that theoretically extinguished the last of the dinosaurs, in Margulis’s phrase, “the system bounces back,” it does so because life’s own predilection for community has systematized itself at the planetary level. What bounces back is neither some atomized assortment of random living beings nor some mystic whole but the Gaian system itself, that is, a distributed but bounded planetary network whose systemic resilience rises above the particular fates of its living components. The Gaian perspective foregrounds, first of all, the autopoietic systematicity of living organization. Restated in immunitary terms, from the moment of life’s first appearance some 3.5 thousand million years ago, every living being in its minimal and bounded quasi-autonomy has needed protection from the sheer physical flux of elements and energies. So prior to any evolutionary development whatsoever, and prior to any gain of safety in collective numbers, in their very origin and emergence from prebiotic conditions, living systems may be thought of as self-immunizing. Stated in a neocybernetic idiom, in their very self-constitution and self-maintenance as membrane-bounded, autopoietic unities, living systems operate to maintain the integrity of their “somatic individuation,” in Varela’s phrase, from the wider abiotic matrixes out of which they emerge. From the primordial cell on, to be alive is to be exempted as much as may be possible from entropic dispersion back into a relatively non-differentiated physical environment. To be alive grants temporary immunity from an eventual return of the living system’s material elements to non-living conditions of non-operation, in short, immunity from being dead.


And finally, the Gaian perspective foregrounds the dynamic coupling of biotic and abiotic organizations. Following upon the arrival of the microbial world as a microcosm distributed across the surface of the earth, the Gaian

system arose as a second-order development. Restated in the idiom of the biopolitical theory with which we began, Gaia theory suggests that in the early evolution of primordial life and its expansion into an operationally coupled symbiotic planetary phenomenon, the global interactions of living beings eventually fell into the systemic form of an immunitary consortium. Microbial life in its integration with the earth, to form and maintain a geobiological system, evolved Gaia as the communal immune system of the biosphere. Subsequent to her encounters with Maturana and Varela, Margulis would go on to suggest that the Gaian system is autopoietic in its own right.<sup>38</sup> And if that is so, then just as the membrane self-produced by a living cell operates to immunize that system as much as possible from incursions from or dispersions into its circumambient environment, so too Gaia's own operational closure as a system, like that of its living elements, forms an immunitary boundary around the biosphere as a whole, a membrane whose upper surface is the atmosphere. Gaia operates to provide life on earth temporary immunity from cosmic extinction. Keeping that vigil going, walking that beat for 3 billion years, has been no paltry accomplishment. The symbiotic tolerance of planetary immunity might be a place to begin a new reflection on human political organization in relation to a planetary ecology we are still only beginning to discover in the wider range of its cooperational diversities.

## Notes

- 1 Frédéric Neyrat, "The Birth of Immunopolitics," trans. Arne de Boever, *Parrhesia: A Journal of Critical Philosophy* 10 (2010): 32. Available online: [http://www.parrhesiajournal.org/parrhesia10/parrhesia10\\_neyrat.pdf](http://www.parrhesiajournal.org/parrhesia10/parrhesia10_neyrat.pdf) (accessed November 27, 2015).
- 2 Francisco J. Varela and Mark Anspach, "Immu-knowledge: The Process of Somatic Individuation," in *Gaia 2—Emergence: The New Science of Becoming*, ed. William Irwin Thompson (Hudson, NY: Lindisfarne Press, 1991), 69.
- 3 Cary Wolfe, *Before the Law: Humans and Other Animals in a Biopolitical Frame* (Chicago: University of Chicago Press, 2013).
- 4 Wolfe, *Before the Law*, 6. See Jacques Derrida, "Autoimmunity: Real and Symbolic Suicides," in *Philosophy in a Time of Terror: Dialogues with Jürgen Habermas and Jacques Derrida*, ed. Giavanna Borradori (Chicago: University of Chicago Press, 2003).
- 5 Roberto Esposito, *Immunitas: The Protection and Negation of Life*, trans. Zakiya Hanafi (Malden, MA: Polity Press, 2011).
- 6 Cited in Roberto Esposito, *Bios: Biopolitics and Philosophy*, trans. Timothy Campbell (Minnesota: University of Minnesota Press, 2008), 186.
- 7 Wolfe, *Before the Law*, 55, 7.

- 8 Ibid., 56, 59; Esposito cited from *Bios*, 186.
- 9 Cary Wolfe, "Life, (Auto)Immunity, Social Theory, and Control" (plenary address at the European Society for Literature, Science, and the Arts (SLSA-EU) conference "Life, in Theory," Turin, Italy, June 2014). Wolfe's interventions on behalf of a systems-theoretical redescription of the immunitary paradigm are crucial for correcting misapprehensions such as that transmitted by Neyrat in remarking how "Esposito criticizes theories of auto-organization, of *autopoiesis* and auto-regulation, namely because they end up 'questioning the idea of exteriority itself'" (Neyrat, "Birth of Biopolitics," 36). Questioning the idea of exteriority is exactly what systems theory, properly understood, does *not* do. Luhmann could not be clearer on this point: "self-referential closure is possible only in an environment, only under ecological conditions." Niklas Luhmann, *Social Systems*, trans. John Bednarz with Dirk Baecker (Stanford: Stanford University Press, 1995), 9.
- 10 This work goes back to seminal publications of Varela, such as Nelson Vaz and Francisco Varela, "Self and Non-Sense: An Organism-Centered Approach to Immunology," *Medical Hypothesis* 4 (1978), and Francisco J. Varela, Antonio Coutinho, Bruno Dupire, and Nelson M. Vaz, "Cognitive Networks: Immune, Neural, and Otherwise," in *Theoretical Immunology*, Part Two, ed. A. S. Perelson (Boston: Addison-Wesley, 1988). For an application of Maturana's thought to immunological theory, see Nelson M. Vaz, "The Specificity of Immunologic Observations," *Constructivist Foundations* 6 (3) (2011). See also Alfred I. Tauber, "Immunology's Theories of Cognition," *History and Philosophy of the Life Sciences* 35 (2013); and "The Cognitivist Paradigm 20 Years Later: Commentary on Nelson Vaz," *Constructivist Foundations*, 6 (3) (2011); and Nelson Vaz, "The Enactive Paradigm 33 Years Later: Response to Alfred Tauber," *Constructivist Foundations* 6 (3) (2011).
- 11 *Gaia: Goddess of the Earth* [TV program], a NOVA documentary (PBS, January 28, 1986).
- 12 Stewart Brand, "The First Whole Earth Photograph," in *Earth's Answer: Explorations of Planetary Culture at the Lindisfarne Conferences*, ed. Michael Katz, William P. Marsh, and Gail Gordon Thompson (New York: Harper and Row, 1977), 186. See also Bruce Clarke, "Steps to an Ecology of Systems: Whole Earth and Systemic Holism," in *Addressing Modernity: Social Systems Theory and U.S. Cultures*, ed. Hannes Bergthaller and Carsten Schinko (Amsterdam: Rodopi, 2011).
- 13 "The insights of Buckminster Fuller initiated this Catalog." Stewart Brand, "Buckminster Fuller," *Whole Earth Catalog*, ed. Stewart Brand (Spring 1969), 3, which article also cites Fuller's definition of synergy.
- 14 See Harold J. Morowitz, *Energy Flow in Biology: Biological Organization as a Problem in Thermal Physics* (New York: Academic Press, 1968), 3.
- 15 Heinz von Foerster, "Laws of Form," *Whole Earth Catalog*, ed. Stewart Brand (Spring 1970), 14.
- 16 "Where the insights of Buckminster Fuller initiated the *Whole Earth Catalog*, Gregory Bateson's insights lurk behind most of what's going on in

- this *Epilog*.” Stewart Brand, “Steps to an Ecology of Mind,” *Whole Earth Epilog*, ed. Stewart Brand (September 1974): 453.
- 17 Lynn Margulis and James E. Lovelock, “The Atmosphere as Circulatory System of the Biosphere: The Gaia Hypothesis,” *CoEvolution Quarterly*, 6 (1975). Earlier that year Margulis wrote to Lovelock to report a series of hopeful if still tentative arrangements she had just worked out to publish one of their co-authored Gaia articles in both a mainstream highbrow science magazine, *Natural History*, and slightly sooner, in the *CoEvolution Quarterly*. Margulis wrote that Brand “is claiming that his journal is responsible and responsive, refuses to compartmentalize science and that my accusation that he’s into food fadism and astrology is totally unfounded ... & since after reading CoQ I find myself sympathetic to his goals, I would hope you will agree to this plan.” Lynn Margulis to James Lovelock, April 29, 1975, Lynn Margulis papers. 
  - 18 These points were driven home by the CQ article’s inclusion of an excerpt from an even more technical, co-written Gaia article, lead-authored by Lovelock, “Atmospheric Homeostasis by and for the Biosphere: The Gaia Hypothesis,” *Tellus* XXVI (1–2) (1974).
  - 19 For instance, he introduces the important matter of operational closure: “the closure, the self-referential-ness, seems to be the hinges upon which the emergent properties of a system turn.” Francisco J. Varela, “On Observing Natural Systems,” *CoEvolution Quarterly* 10 (Summer 1976): 27.
  - 20 Francisco J. Varela, “Not One, Not Two: Position Paper for the Mind–Body Conference,” *CoEvolution Quarterly* 11 (Fall 1976); *Principles of Biological Autonomy* (New York: North Holland, 1979).
  - 21 Ibid.
  - 22 A year earlier, under his Lindisfarne Books imprint, Thompson had edited the essay collection *Earth’s Answer: Explorations of Planetary Culture at the Lindisfarne Conferences* (see note 12 above), including contributions by Stewart Brand, Gregory Bateson, Jonas Salk, E. F. Schumacher, Paolo Soleri, and Lewis Thomas.
  - 23 William Irwin Thompson, ed., *Gaia—A Way of Knowing: Political Implications of the New Biology* (Great Barrington, MA: Lindisfarne Press, 1987).
  - 24 William Irwin Thompson, “Preface,” in *Gaia—A Way of Knowing: Political Implications of the New Biology*, ed. William Irwin Thompson (Great Barrington, MA: Lindisfarne Press, 1987), 9; my emphasis. The observation of observation is a central theme of second-order cybernetics, or again, in von Foerster’s phrase, “the cybernetics of cybernetics.”
  - 25 William Irwin Thompson, “Introduction: The Cultural Implications of the New Biology,” in *Gaia—A Way of Knowing: Political Implications of the New Biology*, ed. William Irwin Thompson (Great Barrington, MA: Lindisfarne Press, 1987), 11–12.
  - 26 Margaret McFall-Ngai et al., “Animals in a Bacterial World, a New Imperative for the Life Sciences,” *PNAS* 110(9) (February 26, 2013). Available online: <http://web.stanford.edu/~fukamit/mcfall-ngai-et-al-2013>.

- pdf (accessed November 28, 2015). “Carl Woese and George Fox opened a new research frontier by producing sequence-based measures of phylogenetic relationships, revealing the deep evolutionary history shared by all living organisms. This game-changing advance catalyzed a rapid development and application of molecular sequencing technologies, which allowed biologists for the first time to recognize the true diversity, ubiquity, and functional capacity of microorganisms” (3229).
- 27 Margulis’s “strong influence has been critical for development in three major arenas: the prevalence of symbiosis as a driving force in evolution of eukaryotes, the central role of the microbial world in the dynamics of the past and present biosphere, and the recognition that the earth is a self-regulating system, that is, the Gaia hypothesis.” Margaret McFall-Ngai, “Truth Straight On: Reflections on the Vision and Spirit of Lynn Margulis,” *The Biological Bulletin* 223 (August 2012): 1. Available online: <http://www.biolbull.org/content/223/1/1.full.pdf> (accessed November 28, 2015).
  - 28 Scott F. Gilbert, Jan Sapp, and Alfred I. Tauber, “A Symbiotic View of Life: We Have Never Been Individuals,” *The Quarterly Review of Biology* 87 (4) (December 2012): 326. Available online: <http://blogs.bu.edu/ait/files/2012/12/SymbioticViewQRB.pdf> (accessed November 28, 2015).
  - 29 See Norman R. Pace, Jan Sapp, and Nigel Goldenfeld, “Phylogeny and Beyond: Scientific, Historical, and Conceptual Significance of the First Tree of Life,” *PNAS* 109 (4) (January 24, 2012). Available online: <http://www.pnas.org/content/early/2012/01/13/1109716109.full.pdf+html> (accessed November 28, 2015).
  - 30 Lynn Margulis, *Symbiosis in Cell Evolution: Microbial Communities in the Archean and Proterozoic Eons*, 2nd edition (New York: W. H. Freeman, 1993), 7. Margulis’s credit for coining the term “holobiont” is affirmed in Seth R. Bordenstein and Kevin R. Theis, “Host Biology in Light of the Microbiome: Ten Principles of Holobionts and Hologenomes,” *PLoS Biology* 13 (8) (August 18, 2015).
  - 31 “Animals diverged from their protistan ancestors 700-800 Mya, some 3 billion years after bacterial life originated and as much as 1 billion years after the first appearance of eukaryotic cells. Thus, the current-day relationships of protists”—microbial eukaryotes—“with bacteria, from predation to obligate and beneficial symbiosis, were likely already operating when animals first appeared.” McFall-Ngai et al., “Animals in a Bacterial World,” 3230.
  - 32 Alfred Tauber notes that “an ecological orientation ... already assumes a subordination of the individual to a collective picture of biological function, and in place of differentiation, integration and coordination serve as organizing principles.” See Alfred I. Tauber, “The Immune System and Its Ecology,” *Philosophy of Science* 75 (April 2008): 228. Available online: <http://blogs.bu.edu/ait/files/2012/08/The-Immune-System-and-Its-Ecology-AIT.pdf> (accessed November 28, 2015).
  - 33 Gilbert, Sapp, and Tauber, “Symbiotic View,” 330. See also McFall-Ngai et al., “Animals in a Bacterial World,” 3231.



- 34 See Ilana Zilber-Rosenberg and Eugene Rosenberg, "Role of Microorganisms in the Evolution of Animals and Plants: The Hologenome Theory of Evolution," *FEMS Microbiology Review* 32 (2008). Available online: <http://onlinelibrary.wiley.com/doi/10.1111/j.1574-6976.2008.00123.x/pdf> (accessed November 28, 2015).
- 35 Thomas C. G. Bosch and Marilyn J. McFall-Ngai, "Metaorganisms as the New Frontier," *Zoology* 114 (2011): 187–8. Available online: <http://labs.medmicro.wisc.edu/mcfall-ngai/papers/11bosch.pdf> (accessed November 28, 2015).
- 36 Lynn Margulis and Dorion Sagan, *What is Life?* (Berkeley: University of California Press, 2000), 189.
- 37 William Irwin Thompson, "The Imagination of a New Science and the Emergence of a Planetary Culture," in *Gaia 2—Emergence: The New Science of Becoming*, ed. William Irwin Thompson (Hudson, NY: Lindisfarne Press, 1991), 24.
- 38 See Bruce Clarke, "Neocybernetics of Gaia: The Emergence of Second-Order Gaia Theory," in *Gaia in Turmoil: Climate Change, Biodepletion, and Earth Ethics in an Age of Crisis*, ed. Eileen Crist and H. Bruce Rinker (Cambridge, MA: MIT Press, 2009), 293–314, and "Autopoiesis and the Planet," in *Impasses of the Post-Global: Theory in the Era of Climate Change*, vol. 2, ed. Henry Sussman (Ann Arbor: Open Humanities Press, 2012). Available online: <http://quod.lib.umich.edu/o/ohp/10803281.0001.001/1:4?rgn=div1;view=fulltext> (accessed November 28, 2015).

## Bibliography

- Bordenstein, Seth R. and Kevin R. Theis. "Host Biology in Light of the Microbiome: Ten Principles of Holobionts and Hologenomes." *PLoS Biology* 13 (8) (August 18, 2015): e1002226. doi:10.1371/journal.pbio.1002226.
- Bosch, Thomas C. G. and Marilyn J. McFall-Ngai. "Metaorganisms as the New Frontier." *Zoology* 114 (2011): 185–90. Available online: <http://labs.medmicro.wisc.edu/mcfall-ngai/papers/11bosch.pdf> (accessed November 28, 2015).
- Brand, Stewart. "Buckminster Fuller." *Whole Earth Catalog*, ed. Stewart Brand (Spring 1969).
- Brand, Stewart. "Steps to an Ecology of Mind." *Whole Earth Epilog*, ed. Stewart Brand (September 1974).
- Brand, Stewart. "The First Whole Earth Photograph." In *Earth's Answer: Explorations of Planetary Culture at the Lindisfarne Conferences*, ed. Michael Katz, William P. Marsh, and Gail Gordon Thompson, 184–8. New York: Harper and Row, 1977.
- Clarke, Bruce. "Autopoiesis and the Planet." In *Impasses of the Post-Global: Theory in the Era of Climate Change*, vol. 2, ed. Henry Sussman. Ann Arbor: Open Humanities Press, 2012. Available online: <http://quod.lib.umich.edu/o/ohp/10803281.0001.001/1:4?rgn=div1;view=fulltext> (accessed November 28, 2015).
- Clarke, Bruce. "Neocybernetics of Gaia: The Emergence of Second-Order Gaia



- Theory." In *Gaia in Turmoil: Climate Change, Biodepletion, and Earth Ethics in an Age of Crisis*, ed. Eileen Crist and H. Bruce Rinker, 293–314. Cambridge, MA: MIT Press, 2009.
- Clarke, Bruce. "Steps to an Ecology of Systems: Whole Earth and Systemic Holism." In *Addressing Modernity: Social Systems Theory and U.S. Cultures*, ed. Hannes Bergthaller and Carsten Schinko, 259–88. Amsterdam: Rodopi, 2011.
- Derrida, Jacques. "Autoimmunity: Real and Symbolic Suicides." In *Philosophy in a Time of Terror: Dialogues with Jürgen Habermas and Jacques Derrida*, ed. Giavanna Borradori, 85–136. Chicago: University of Chicago Press, 2003.
- Esposito, Roberto. *Bios: Biopolitics and Philosophy*, trans. Timothy Campbell. Minnesota: University of Minnesota Press, 2008.
- Esposito, Roberto. *Immunitas: The Protection and Negation of Life*, trans. Zakiya Hanafi. Malden, MA: Polity Press, 2011.
- Foerster, Heinz von. "Laws of Form." *Whole Earth Catalog*, ed. Stewart Brand (Spring 1970).
- Gaia: Goddess of the Earth* [TV program]. A NOVA documentary. PBS, January 28, 1986.
- Gilbert, Scott F., Jan Sapp, and Alfred I. Tauber. "A Symbiotic View of Life: We Have Never Been Individuals." *The Quarterly Review of Biology* 87 (4) (December 2012): 325–41. Available online: <http://blogs.bu.edu/ait/files/2012/12/SymbioticViewQRB.pdf> (accessed November 28, 2015).
- Lovelock, James E. and Lynn Margulis. "Atmospheric Homeostasis by and for the Biosphere: The Gaia Hypothesis." *Tellus* XXVI (1–2) (1974): 1–10.
- Luhmann, Niklas. *Social Systems*, trans. John Bednarz with Dirk Baecker. Stanford: Stanford University Press, 1995.
- Margulis, Lynn and Dorion Sagan. *What is Life?* Berkeley: University of California Press, 2000.
- Margulis, Lynn and James E. Lovelock. "The Atmosphere as Circulatory System of the Biosphere: The Gaia Hypothesis." *CoEvolution Quarterly* 6 (1975): 31–40.
- Margulis, Lynn. *Symbiosis in Cell Evolution: Microbial Communities in the Archean and Proterozoic Eons*. 2nd ed. New York: W. H. Freeman, 1993.
- McFall-Ngai, M. "Truth Straight On: Reflections on the Vision and Spirit of Lynn Margulis." *The Biological Bulletin* 223 (August 2012): 1–2. Available online: <http://www.biolbull.org/content/223/1/1.full.pdf> (accessed November 28, 2015).
- McFall-Ngai, M., M. G. Hadfield, T. C. Bosch, H. V. Carey, T. Domazet-Lošo, A. E. Douglas, N. Dubilier, G. Eberl, T. Fukami, S. F. Gilbert, U. Hentschel, N. King, S. Kjelleberg, A. H. Knoll, N. Kremer, S. K. Mazmanian, J. L. Metcalf, K. Nealson, N. E. Pierce, J. F. Rawls, A. Reid, E. G. Ruby, M. Rumpho, J. G. Sanders, D. Tautz, and J. J. Wernegreen. "Animals in a Bacterial World, a New Imperative for the Life Sciences." *PNAS* 110 (9) (February 26, 2013): 3229–36. Available online: <http://web.stanford.edu/~fukamit/mcfall-ngai-et-al-2013.pdf> (accessed November 28, 2015).
- Morowitz, Harold J. *Energy Flow in Biology: Biological Organization as a Problem in Thermal Physics*. New York: Academic Press, 1968.
- Neyrat, Frédéric. "The Birth of Immunopolitics," trans. Arne de Boever. *Parrhesia: A Journal of Critical Philosophy* 10 (2010): 31–8. Available online: <http://>

- [www.parrhesiajournal.org/parrhesia10/parrhesia10\\_neyrat.pdf](http://www.parrhesiajournal.org/parrhesia10/parrhesia10_neyrat.pdf) (accessed November 27, 2015).
- Pace, Norman R., Jan Sapp, and Nigel Goldenfeld. "Phylogeny and Beyond: Scientific, Historical, and Conceptual Significance of the First Tree of Life." *PNAS* 109 (4) (January 24, 2012): 1011–8. Available online: <http://www.pnas.org/content/early/2012/01/13/1109716109.full.pdf+html> (accessed November 28, 2015).
- Tauber, Alfred I. "Immunology's Theories of Cognition." *History and Philosophy of the Life Sciences* 35 (2013): 239–64.
- Tauber, Alfred I. "The Cognitivist Paradigm 20 Years Later: Commentary on Nelson Vaz." *Constructivist Foundations* 6 (3) (2011): 342–4.
- Tauber, Alfred I. "The Immune System and Its Ecology." *Philosophy of Science*, 75 (April 2008): 224–45. Available online: <http://blogs.bu.edu/ait/files/2012/08/The-Immune-System-and-Its-Ecology-AIT.pdf> (accessed November 28, 2015).
- Thompson, William Irwin, ed. *Gaia—A Way of Knowing: Political Implications of the New Biology*. Great Barrington, MA: Lindisfarne Press, 1987.
- Thompson, William Irwin. "The Imagination of a New Science and the Emergence of a Planetary Culture." In *Gaia 2—Emergence: The New Science of Becoming*, ed. William Irwin Thompson, 11–29. Hudson, NY: Lindisfarne Press, 1991.
- Varela, Francisco J. "Not One, Not Two: Position Paper for the Mind–Body Conference." *CoEvolution Quarterly* 11 (Fall 1976): 62–7.
- Varela, Francisco J. "On Observing Natural Systems." *CoEvolution Quarterly* 10 (Summer 1976): 26–31.
- Varela, Francisco J. and Mark Ansapach. "Immu-knowledge: The Process of Somatic Individuation." In *Gaia 2—Emergence: The New Science of Becoming*, ed. William Irwin Thompson, 68–85. Hudson, NY: Lindisfarne Press, 1991.
- Varela, Francisco J. *Principles of Biological Autonomy*. New York: North Holland, 1979.
- Varela, Francisco J., Antonio Coutinho, Bruno Dupire, and Nelson M. Vaz. "Cognitive Networks: Immune, Neural, and Otherwise." In *Theoretical Immunology*, Part Two, ed. A. S. Perelson, 359–75. Boston: Addison-Wesley, 1988.
- Vaz, Nelson and Francisco J. Varela. "Self and Non-Sense: An Organism-Centered Approach to Immunology." *Medical Hypothesis* 4 (1978): 231–67.
- Vaz, Nelson. "The Specificity of Immunologic Observations." *Constructivist Foundations* 6 (3) (2011): 334–42.
- Vaz, Nelson. "The Enactive Paradigm 33 Years Later: Response to Alfred Tauber." *Constructivist Foundations* 6 (3) (2011): 345–51.
- Wolfe, Cary. "Life, (Auto)Immunity, Social Theory, and Control." Plenary address at the European Society for Literature, Science, and the Arts (SLSA-EU) conference "Life, in Theory," Turin, Italy, June 2014.
- Wolfe, Cary. *Before the Law: Humans and Other Animals in a Biopolitical Frame*. Chicago: University of Chicago Press, 2013.
- Zilber-Rosenberg, Ilana and Eugene Rosenberg. "Role of Microorganisms in the Evolution of Animals and Plants: The Hologenome Theory of Evolution." *FEMS Microbiology Review* 32 (2008): 723–35. Available online: <http://onlinelibrary.wiley.com/doi/10.1111/j.1574-6976.2008.00123.x/pdf> (accessed November 28, 2015).